Capturing concern: Understanding perceptions of wildlife-associated disease risk

February 2009

HDRU Series No. 09-1

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Key Words: risk perception, wildlife disease, zoonoses, culture, heuristics, cognitive thought processing, affective thought processing

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EXECUTIVE SUMMARY

The purpose of this paper is to explore application of risk analysis to research on public perceptions of wildlife disease. We review literature that identifies wildlife disease as a growing concern and that reveals how approaches to risk research have been used in studying public perceptions of wildlife diseases. This report also includes a review of theoretically supported approaches to risk perception research that have not yet been applied to the context of wildlife diseases, drawing from: (1) cultural theories of risk, (2) subliminal linkage models applied to risk perception, and (3) theories about activation of heuristics relevant to risk perceptions.

The report identifies the following key points:

- Scientists, the public, and wildlife and disease management agencies are becoming increasingly concerned about wildlife diseases, but likely for different reasons. As disease outbreaks become more common, scientists estimate greater potential impacts on society, based on technical risk assessments. The social and cultural contexts in which diseases emerge and are framed additionally influence public perceptions of disease risk. Management agencies responsible for human safety and the informed stewardship of resources are impacted by increasing prevalence and severity of emerging diseases as well as a populous more concerned about disease risks.

- Targeted communication is one management tool that wildlife and disease management agencies can use to decrease public exposure to risks, by aiding people in making informed decisions about how to personally mitigate a risk's impact on their lives. Communications have also been used to create support for agency management actions that reduce risks by manipulating the ecology of a disease.

- Researchers have used various approaches to risk analysis to measure public concern about wildlife diseases. Some studies measure stakeholder levels of concern, while others additionally account for specific factors that lead to risk perception formation. Studies accounting for specific factors have produced more comprehensive and targeted recommendations for communications that an agency could implement, compared to studies measuring only level of concern.

- Risk perception research has identified additional constructs important to public formation of risk perceptions that have not been used in research on wildlife diseases. These include: (1) social and cultural influences, (2) heuristic activation, and (3) affective and cognitive thought processing. Risk analysis theory supports including these constructs in research on risk perceptions across disciplines.

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ACKNOWLEDGMENTS

We would like to thank the faculty, staff, and students in the Human Dimensions Research Unit at Cornell University who provided valuable input and support in reviewing this report. Additionally we would like to thank our colleagues Kevin Castle and Kirsten Leong of the National Park Service for their time in reviewing this report and for their helpful comments.

Funding for this study was provided by the National Park Service Biological Resource Management Division, USDI 56946-CESU NPS HP AVIAN INFLUENZA, OSP# 56946, by the Cornell University Agricultural Experiment Station federal formula funds, Project Number NYC-147439, received from Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, and by funding from the Doris Duke Conservation Fellowship. The opinions, findings, conclusions or recommendations expressed in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government.

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Introduction

As concern over wildlife-associated diseases (WDs) proliferates across scientific and public realms, wildlife and disease management agencies have identified a need to understand what risks people perceive related to infectious diseases (Brook and McLachlan 2006; Dorn and Mertig 2005). We use the phrase "wildlife-associated diseases" to describe diseases for which at least one species of wildlife (i.e., non-domesticated animals) acts as a host population. These include zoonotic diseases (i.e., diseases able to spread between animals and humans, including vector-borne diseases) and non-zoonotic diseases. (i.e., diseases that are transmitted between animal species, but do not usually affect humans).

Literature from the fields of wildlife and disease management indicates that researchers believe that an understanding of public risk perceptions about WDs can provide for more effective risk management (Decker et al. 2006). Studies have typically investigated stakeholder risk perceptions with the aim of improving communications designed to help the public make informed decisions about risks posed by WDs (Brunet and Houbaert 2007; Peltz et al. 2007; Stronen et al. 2007; Brook and McLachlan 2006; Zielinski-Gutierrez and Hayden 2006; Wilson et al. 2005).

This document explores the benefits of researching human dimensions of WDs from a risk analysis perspective. Based on a literature review, we discuss how insights gained through research on risk perceptions about WDs have been used to construct recommendations for communication aspects of wildlife disease management. After examining the past, we look to the future of social science research on WDs and review theoretically important approaches to studying risk perceptions that have not yet been used in WD research. We explore the advantages that experts in risk perception theory have given for using each approach to better understand the public's risk perceptions. Next, we discuss how these could be integrated for use in research on risk perceptions about WDs. We begin this report, however, by reviewing why WDs are a growing concern, and identifying who cares.

Concern about wildlife disease

Wildlife-associated diseases (WDs) are a growing concern for scientists and the lay public (Gortázar et al. 2007). On the most basic level, concern about WDs is increasing because disease outbreaks are occurring and being recorded more often than ever before in modern times (Jones et al. 2008). A growing human population, global movement of humans and exotic animals, and intensified encroachment on wildlife habitat for agricultural and urban development are principal influences on the expansion in wildlife-associated zoonoses and epizootics (Munson et al. 2008; Chomel et al. 2007; Wobeser 2006; Baretto 2003). Because these trends will likely accelerate, so too may the incidence of WDs. In addition, global climate change is expected to facilitate spread of WDs by amplifying vulnerability of potential host populations to infection through increased environmental stress, lengthening the pathogen transmission season, and expanding the geographic ranges of pathogens and vectors (Jones et al. 2008; Kutz 2008; IPCC 2007; Intl. Assoc. of Fish and Wildlife Agencies 2005).

Data from the 1940s through the 1990s indicate that emergence of new wildlife-driven (as opposed to domesticated animal-driven) zoonoses increased each decade, even after controlling for increased monitoring and reporting efforts (Jones et al. 2008). Diseases originating in wildlife currently constitute the majority of all newly discovered or rapidly proliferating diseases that infect humans worldwide (Jones et al. 2008). Estimated increases in zoonoses do not include the concurrent proliferation in non-zoonotic diseases that are transmitted from wildlife to domestic animals. Non-zoonotic diseases present risks due to the economic and emotional impacts they can have on livestock and pet owners, as well as negative impacts on the wildlife populations themselves (Brunet and Houbaert 2007; Fernández et al. 2006; Wobeser 2006).

Who is concerned, and why?

While an increase in disease outbreaks is the common denominator for growing concerns, reasons for increasing concern over WDs vary across stakeholder groups. Scientists, the public, and management agencies are three broad groups we focus on here.

Scientists typically rely on "technical" risk analyses to evaluate the risk associated with a given object or event (Renn 1998, 1992). In technical analyses, WD risk is established by determining the relative frequency of an event over time (e.g., a person or domesticated animal becoming ill or dying from some disease) weighted by the physical harm experienced (Klinke and Renn 2002). Technical risk essentially equals event probability multiplied by severity of the event (Renn 1992, Slovic 1987). Therefore, scientific concern centers on the rising incidence (a measure of the number of new cases of a disease emerging over a specified period of time) and prevalence (a measure of the presence of a disease in a population at a given point in time) of WDs as predictors of their relative impacts on human and wildlife populations (Nusser et al. 2008). An expected increase in incidence and prevalence of WDs translates into negative impacts on human and wildlife populations occurring more frequently, thus producing higher technical risk perceptions.

Risk perception research indicates that technical, or "expert," evaluations of risk often differ substantially from public, or "lay," risk perceptions (Raude 2005; Klinke and Renn 2002; Slovic 1987). Technical assessments focus on the risk object (e.g., a disease or disease vector) or event (e.g., an outbreak) and lay perceptions usually situate this object or event in a larger context (Renn 1992).

The public, or lay people, form risk perceptions by relying on additional factors, typically neglected in technical risk analyses, including: (1) the influence of culture and society (e.g., deeply-engrained cultural values and norms, social institutions, and mass media) (Lupton 1999; Slovic 1993; Douglas 1992; Rayner 1992; Douglas and Wildavsky 1982), (2) activation of heuristics (i.e., psychological shortcuts that facilitate automatic thought processing) (Kahneman and Frederick 2002; Sherman et al. 2002; Tversky and Kahneman 1974), and (3) the role of affect, or emotional cues, versus cognitive reasoning (Keller et al. 2006; Slovic and Peters 2006; Loewenstein et al. 2001). We examine these influences in greater detail in a later section.

Lay people may rely on one or all of the aforementioned influences (including technical risk assessments) when forming risk perceptions (Lupton 1999). An individual may be influenced by these stimuli to varying degrees; for example, one may rely mainly on cultural norms and social institutions, but take technical risk assessments into account as a supporting influence (Kasperson 1992). Whereas scientists are depicted as using the same formula for assessing risk across multiple types of risks (Renn 1998; Slovic 1987), the type of risk a lay individual encounters may, for example, affect whether he has a relevant heuristic for activation, or whether he has strong cultural values relating to the issue. This will affect how he generates risk perceptions.

Because members of the public potentially differ so widely in their means for constructing risk perceptions, it is hard to produce an objective standard to demonstrate that public concern about WDs is increasing. Changes in several of the theoretically identified influences on public risk perceptions do, however, allow us to postulate that concerns are growing for at least a substantial portion of the public:

- Members of the public relying, in whole or in part, on technical risk assessments would experience growing concern over WDs for the same reasons as scientists.

- Members of the public relying on mass media would experience growing concern as media attention to WDs expands. At least for some major zoonotic diseases (e.g., Avian Influenza and West Nile Virus), amount of media coverage in major US newspapers (e.g., *New York Times*, *Washington Post*, *USA Today*) closely parallels occurrence of disease events (Evensen, unpublished). The public, therefore, is exposed to more information about diseases as they proliferate. Risks are often sensationalized in the media, amplifying risk perceptions beyond technical assessments of risk (Kasperson et al. 1988). If scientists, through technical risk assessments, are becoming increasingly concerned, then we can expect members of the public who rely on mass media influences when forming risk perceptions to exhibit increased concern as well. Signorielli (1993) provides research supporting the belief that members of the public rely heavily on media sources when constructing risk perceptions, especially for risks situated in environmentally-related realms.

- Members of the public relying on social institutions and inter-personal connections to form risk perceptions would experience growing concern as they become increasingly aware of risks through these information channels. As more people directly experience risks or hear about risks through mass media, they will pass this information on to family, friends, and colleagues (Tyler and Cook, 1984). Mazur (1981) provides research supporting the hypothesis that increased information about a risk, irrespective of its valence, increases concern.

- Members of the public relying on affective processing would experience increased concern because sensational portrayals of risks, whether through media coverage or interpersonal conversation, could increase fear (Kasperson et al. 2003).

- Members of the public relying on cognitive processing would experience increased concern, because they would evaluate the risks based on attributes of the diseases and their impacts on society, which scientists have identified as increasing (Jones et al. 2008; Kutz et al. 2008; Wobeser 2006).

- Members of the public relying on heuristics could increase or decrease in concern about WDs. A growing number of risk events would be available to enhance the probability of heuristic activation, and activated heuristics could help people make a quick decision as to whether a risk is threatening or benign. For example, one could develop the heuristic that people simply enjoy talking about scary topics, and thus as he hears more information about infectious diseases he may disregard the information. On the other hand, one could develop the heuristic that an infectious disease in his area makes it unsafe for his children to play outside, increasing his concern as he learns of new disease events. The availability heuristic, which uses memorable information or images about one risk (e.g., a disease) to stand in for making decisions about other risks (e.g., a different disease), is perhaps the most commonly used heuristic in forming risk perceptions (Keller et al. 2006). For people employing the availability heuristic, it is likely that stories, images, or even raw numbers on increasing infections from disease would cause increasing concern.

Wildlife and disease management agencies vary in their methods for constructing risk perceptions, running the gamut from relying solely on technical assessments to depending on citizens' reasons for concern to help them define what constitutes a risk (Fischhoff 1995). Wildlife and disease management agencies (e.g., the U.S. Department of the Interior, state departments of natural resources, federal and state health agencies, etc.) are, in part, charged with the purpose of mitigating negative impacts caused by WDs, whether through an explicit directive or through mandates for the responsible management of public trust resources (e.g., see http://www.cdc.gov/about/organization/mission.htm; 16 U.S.C. 1). As disease outbreaks occur more frequently, agencies must increasingly dedicate resources to disease management, prevention, and control.

What is being done to manage wildlife disease?

Two primary pathways exist for a management agency to reduce potential negative impacts: (1) it can try to reduce the prevalence of the risk object (e.g., through controlling vector populations, managing habitat, etc.), or (2) the agency can assist the public in avoiding the risk by helping people make informed personal decisions (Leiss 1996). For the purposes of this paper, we focus on the latter management option. Authorities responsible for risk mitigation often pursue this second pathway by means of communication with the public (Dudo et al. 2007). Communications range from targeted information sharing to listening to, investigating, and evaluating specific stakeholder concerns (IAP2, 2007). Communications can also help management agencies achieve risk mitigation objectives even if they choose primarily to intervene in the ecology of the disease; agencies can use communications to investigate public concerns and incorporate public opinion into decision-making on management actions, which has been shown to increase social support for management actions (Chess and Purcell 1999;

Fischhoff 1995). Social support is critical for effective management of natural resources (Needham and Vaske 2008; Selin et al. 2000).

The field of risk analysis examines risk perceptions as a way to measure the most relevant attitudes and beliefs about some issue of concern. Research that improves understanding of risks people perceive to be associated with a disease, and why, could help an agency evaluate two important questions:

1. Is the public's understanding of the disease accurate and adequate?
2. Are there concerns that the agency was previously unaware of that should be considered in managing the disease?

Answers to these questions could help an agency target its communications to best meet the public's needs, and tailor its management actions to address stakeholder concerns (Fischhoff 1995).

Risk analysis has been applied to WD management only recently. The earliest peer-reviewed journal article we could find that focused on this topic was a 1997 article on risk perceptions about Lyme disease (Shadick et al.). Since then, approximately two dozen articles have discussed perceived risk of WDs. This research has demonstrated the potential value of understanding stakeholder risk perceptions for informing public communications, and has revealed a variety of ways risk perceptions can be studied.

Peer-reviewed research published on risk perceptions of WDs can be separated into two categories. The first category measures risk perceptions about a WD as one component of research meant to inform management of something other than a wildlife disease (e.g., to develop better monitoring mechanisms for evaluating human health [Armstrong et al. 2001]). The second category consists of studies that measure risk perceptions with the explicit objective of gathering data to inform recommendations for management of a specific disease, usually in a specific context. Given this document's goal of examining how social science research can aid wildlife disease management, the remainder of this section explores risk perception research about WDs that fits into this second category. This category can be divided further into two approaches:

1. Research that measures risk perceptions by quantifying the level of perceived risk (e.g., Gstraunthaler and Day 2008; Peltz et al. 2007; Wilson et al. 2005; Vaske et al. 2004; Shadick et al. 1997). These studies do not explore how perceptions are formed.
2. Research that quantifies perceived risk, but also makes an effort to identify particularly salient factors that impact how people think about WD issues. These studies employ qualitative methods such as focus group interviews, attendance at town meetings, or other similar methodologies to identify the contributing factors (e.g., Brunet and Houbaert 2007; Brook and McLachlan 2006; Dorn and Mertig 2005; and particularly Zielinski-Gutierrez and Hayden 2006).

In the next section we present two examples of each of these research approaches. These examples demonstrate some ways in which the second approach can benefit wildlife disease management more significantly than the first.

What is being done: Examples of research approaches

The first two examples we present measure levels of public risk perceptions with respect to Avian Influenza and West Nile Virus. Both studies gather data revealing that different segments within a given population vary in their levels of perceived risk. The authors note that this variation indicates a need to target communications to individual sub-populations. A discussion of these studies follows the examples.

Example 1 (category 1): Risk perceptions about Avian Influenza (Peltz et al. 2007)

Peltz et al. (2007) present a study that compares two populations across their risk perceptions about an outbreak of avian influenza in Israel. One population was sampled from the area in which the outbreak occurred, and the other sample was representative of the nation at large. The two populations were examined for significant differences in risk perceptions with the ultimate goal of helping management agencies design and select appropriate communication tools for the differing contexts. The researchers measured risk perception by asking respondents to report the extent to which they felt fear, indifference, stress, and hope about the avian influenza outbreak. The results revealed that respondents in the area in which the outbreak occurred had significantly lower levels of fear and stress (there was no significant difference on the other two measures). The authors report that these results indicate a "need [for agencies] to direct their effort to disseminate selective, relevant, timely necessary information to selective populations in the country, in order to reduce unnecessary distress and unwanted behavior, which might be different in different parts of the same country."

Example 2 (category 1): Risk perceptions about West Nile Virus (Wilson et al. 2005)

Wilson et al. (2005) report on research that assessed how residents of Ottawa, Canada, perceive risks about West Nile Virus (WNV). The researchers measured perceived risk to self by asking respondents when the City of Ottawa should spray larvicides and adulticides to kill mosquitoes: before local detection of WNV, after WNV is found in a bird, after a human infection, or never. Respondents could also elect no response if they desired more information on effects of spraying before making a decision. This question was designed to indicate the degree to which residents were concerned about WNV. Results indicated that 19.3% supported spraying before any detection of WNV, 33.4% supported spraying after WNV is found in a bird, and 33.4% desired more information to make a decision. The authors state that, "The findings of this survey emphasize the need for public education, especially regarding West Nile awareness, with an emphasis of personal protective behaviours. Improved and targeted public health messages, and the ongoing evaluation of such interventions, are key to minimizing the impact of West Nile Virus."

These two examples reveal that risk perception research focusing on WDs has produced recommendations with potential to help management authorities design more effective public communications. Actual use and effectiveness of these recommendations in public information efforts have not been evaluated. Even without evaluation, examination of the recommendations

reveals limitations. For example, the avian influenza research purportedly provides information to "reduce unnecessary stress and unwanted behavior." Management agencies would be able to achieve this behavioral purpose more readily if they not only understood how levels of fear and stress differed across the study populations, but also had specific insight about how the disease or context in which the disease emerged led to these stresses and fears. With this information, communications could address specific factors advancing concerns. Alternatively, dialogues could be set up between an agency and the public to discuss concerns that additional information about the disease may not be able to remedy readily.

The West Nile Virus research stresses that its results point to a need for "public education." The authors state that this will help people unfamiliar with mosquito spraying make decisions on whether it is necessary or not, and will help people who do not see WNV as a significant health problem to view it as such, and change their behaviors accordingly (Wilson et al. 2005). This research also has limitations when scrutinized. For example, public education might be more effective if agencies knew why people who support spraying for mosquitoes before WNV is detected are supportive of this action. Is it because, as the authors assume, that their concern about WNV is extremely high? Or, alternatively, do those individuals simply hate mosquitoes biting them and/or have little concern over the risks posed by chemical spraying? Similarly, people who are never supportive of spraying may actually realize that WNV poses serious risks, but they may consider the risks of spraying more threatening to human, wildlife, or environmental health. For such individuals, increased information about why WNV poses health risks may do little to change attitudes or behaviors. Knowing why people do or do not support spraying would help management authorities identify the likelihood of "public education" being effective.

The next two examples analyze important factors influencing risk perceptions about West Nile Virus and Bovine Tuberculosis. Both of these studies investigate the relative contributions of a range of influences on overall disease-related risk perceptions. The authors note that knowledge of specific concerns can help inform communications that are particularly relevant to targeted audiences. We note that these studies exhibit greater potential to inform effective targeted communication than the previous examples. A discussion of these studies follows the examples.

Example 3 (category 2): Risk perceptions about Bovine TB (Brook and McLachlan 2006)

Brook and McLachlan (2006) offer research that measured farmers' risk perceptions across several factors that may lead to perceptions of tuberculosis risk. These factors were identified through focus group interviews and town meetings. Data were collected from 786 farmers living near a Canadian National Park with elk infected with Bovine Tuberculosis (TB). Most of the factors posited as leading to risk perceptions focused on previous experience (e.g., observations of elk or deer interacting with cattle, number of deer and elk observations over the past five years). Results showed that the frequency with which elk were observed on the farmers' properties was the best predictor of the variance in risk perceptions. As this one variable, which does not provide great information about the disease, was the main predicting factor for risk perceptions, the authors suggest their results reveal that, "Better access to information about TB will help farmers reduce their vulnerability to disease. Of particular importance is communicating the ways that TB can be transmitted between elk and cattle. A better understanding of the environmental and farm management variables that influence elk use of the landscape would also help farmers understand the risks involved and help identify best practices appropriate for their operation."

Example 4 (category 2): Risk perceptions about West Nile Virus (Zielinski-Gutierrez and Hayden 2006)

Zielinski-Gutierrez and Hayden (2006) detail a comparative study of risk perceptions about West Nile Virus conducted in Colorado. This work used focus-group interviews in areas of high and low disease transmission to develop a model for how community members establish perceptions of WNV risk. The research was qualitative and sought to identify the factors that were most important to formation of risk perceptions. All focus group interviews used open-ended questions, and the researchers coded transcripts of eleven focus group discussions to identify emergent themes. The researchers identified several factors working in concert that contributed to risk perceptions, including perceptions of transmission probability and local ecology, characteristics facilitating risk emergence, actions of local government, and cultural influences such as information sources. These findings led the authors to: (1) identify aspects of local ecology to focus agency communications on, (2) identify specific segments of the public to target agency communications toward, and (3) provide suggestions for proactive stakeholder involvement in areas where the disease is not yet present. The authors further "suggest that models which explicitly include perceived disease proximity and local ecology be used or even developed to guide WNV prevention messages."

By comparing Examples 3 and 4 to the first two examples, we see that studies measuring the influence of specific factors on risk perception have greater potential to affect WD management positively than studies investigating level of perceived risk. The Bovine TB study identifies specific foci for agency communications about the disease. By recognizing the relative influence of various factors on overall risk perceptions, Brook and McLachlan (2006) were able to identify the most pressing and meaningful issues to cover in public communications. The 2006 West Nile Virus study also provides foci for recommendations for risk communications, by detailing how technical risk assessments are only part of lay risk perceptions, and identifying several important influences on risk perception formation, beyond transmission probability, that communications could pursue.

The Bovine TB study focused exclusively on demographic factors and history of experience with disease and disease vectors as the potential factors influencing risk perception formation; Zielinski-Gutierrez and Hayden (2006) go one step further and inspect characteristics of the disease, the social and biological contexts in which the disease emerged, and cultural influences. Zielinski-Gutierrez and Hayden (2006) suggest development and use of models as a way to ensure that research on risk perceptions of WNV and similar diseases captures all the relevant factors influencing perception formation. They advocate an empirically justified model that could be used to guide future research on risk perceptions about WNV. While we recognize the value of such a focused model, we believe it is possible to construct a more broadly applicable model for studying risk perception formation with respect to any WD. A general model would include all those constructs important to lay perceptions of risk, but typically neglected in technical analyses, that were identified in the previous section. We discuss these constructs in depth in the following section.

Additional approaches to risk analysis research

The constructs elaborated upon in this section represent important categories of factors influencing risk perception formation that have generally been neglected in risk perception research about WDs. A few studies, such as those detailed in examples 3 and 4 above, have included some of these elements, but only as an end product of the research, not as an input into the study. For example, Zielinski-Gutierrez and Hayden (2006) found that cultural background was important in influencing risk perception formation, but they did not specifically set out to identify the effects of cultural experiences, values, or norms on risk perceptions. No WD research has used the constructs elaborated upon in this section (i.e., cultural background, activation of heuristics, and affective and cognitive thought processing) to develop a methodology for identifying factors leading to risk perceptions, although their use in this manner has been supported theoretically and empirically in other fields of risk analysis (e.g., risks from mad-cow disease and nuclear energy [Krimsky and Golding 1992]). If constructs such as these or others are believed to play a role in affecting development of all risk perceptions, then WD risk perception research would benefit from a comprehensive and systematic investigation of these constructs (Kasperson et al. 2003, Renn 1998).

Research of this type is supported by Renn (1992), who offers a survey of approaches used to analyze risk perceptions (e.g., actuarial approach, probabilistic risk analysis, economics of risk, psychology of risk, social theories of risk, cultural theory of risk). He makes clear the limitations of using any single approach and advocates integrating perspectives to generate a more inclusive explanation of public risk perceptions. Kasperson et al. (2003) effectively bring together many of these perspectives in their “Social Amplification of Risk Framework” (SARF). We draw on the SARF and a combination of other models that are specific to particular constructs to show how these tools can be used to identify factors affecting risk perception formation. We begin by describing constructs at the foundation of how people form risk perceptions, and then move to influences that help build off of this foundation.

Table 1: Approaches to risk perception research beyond technical risk assessments		
Category	*Key tenets*	*When used*
Social and cultural influences	This category presents a broad array of factors ranging from childhood experiences and upbringings, to societal interpretations of risks in the past, to education, religious beliefs, and contemporary interpretations of risks offered by social organizations.	Culture serves minimally as a substrate on which people build risk perceptions through other channels (Kasperson 1992). Cultural background can predispose an individual to cognitive or affective processing, or help one develop heuristics that could be activated later in life. Cultural influences can even condition how individuals define risk severity, a critical component of technical risk assessments (Douglas, 1992).
Heuristic activation	Heuristics are mental shortcuts to facilitate decision-making that are either innate to human beings' existence (i.e., evolutionarily engrained), or that are developed over time from exposure to information that helps people condense decisions into decision-making categories.	Heuristics are activated when: (1) characteristics of a risk event or object are perceived as sufficiently similar to other risks that humans (or our evolutionary ancestors) have dealt with (Tversky and Kahneman 1974), or (2) society frames the risk in such a manner that people construct sub-conscious devices for comparing the risk to other known risks (Kasperson et al. 2003).
Affective / Cognitive thought processing	People can make decisions about risks by consciously considering available information and constructing calculated judgments, and/or they can rely on emotions such as fear, hopelessness, worry, happiness, and delight.	Many people are predisposed to use one type of thought processing more often than the other (Raude et al. 2005), but characteristics of a risk, or of how the risk is portrayed (e.g., vividness and perceived immediacy) can lead people to favor cognitive or affective processing.

Cultural background

Culture is a foundational lens through which events and phenomena are interpreted (Kasperson et al. 2003; Lupton 1999; Douglas 1992; Rayner 1992). Cultural theories of risk perception formation emphasize influences such as information from: informal social networks, community organizations, news media, government agencies, educational training, political arenas, and cultural norms (Lupton 1999; Douglas 1992; Douglas and Wildavsky 1982). All of these influences shape the way the public think about risks, even before they emerge. Culture's influence on risk perception formation comes primarily before the risk event itself, as culture acts on society by predisposing people to view and interpret phenomena in particular ways (Douglas 1992). Cultural influences affect risk perception formation by helping people to create heuristics over time, which may then be activated by a risk event, influencing cognitive and affective processing (Kasperson et al. 2003).

Risk perception and media experts have identified media coverage of risk objects and events as one of the most important and concretely identifiable cultural influences on risk perception formation (Kasperson et al. 2003, Signorielli 1993; Kasperson et al. 1988). While media exposure, in the historical sense, can be considered a cultural influence that operates through making information available for forming heuristics (Sherman et al. 2002), media coverage of an emergent risk event is more appropriately categorized as a cultural influence that affects the ancillary context for the risk. We define "ancillary context" as the set of risk perceptions associated with a risk that are not attributable to the risk object or risk event (e.g., perceived risks based on responses to the threat, or perceptions due to lack of information, or too much information, available about the threat) (see Heberlein [2004] and Beck [1999] for examples of this concept).

The agenda-setting function of the media influences which issues society tends to think about (Downs 1972), affecting heuristic development and ancillary risk context. Substantial evidence suggests that the media's reporting on risk-related events does not mirror actual prevalence of such events (af Wåhlberg & Sjöberg 2000; Mazur 1981; Combs and Slovic 1979), leading to emphasis on certain risks, and relative neglect of others (Kasperson et al. 2003; Slovic 1986). Over time, such a trend could lead to heuristic development about which types of issues are major concerns (Sherman et al. 2002**)**. Agenda setting may also increase vividness of a risk, prompting affective processing, or it may induce information seeking behavior, encouraging cognitive processing (Loewenstein et al. 2001; Downs 1972). Depending on how risks are treated, both historically and during a risk event, media coverage may amplify (or attenuate) public perceptions of risk compared to scientific risk assessments (Kasperson et al. 2003). Media coverage may, for example, allow individuals to perceive a threat as only salient to other people, or it may excite fear by presenting a hazard and no means for dealing with it (Dudo et al. 2007; Roche and Muskavitch 2003).

History of experience

Past experience – whether direct or indirect, explicitly acknowledged or taken for granted – frames perceptions of future experiences with the same risk or same type of risk, often through development of heuristics (Frederick 2002; Kahneman and Frederick 2002; Klinke and Renn

2002; Slovic 1992; Chaiken 1980; Tversky and Kahneman 1974). History of experience could involve contracting a disease, but experience can be vicarious as well. The public experiences risk objects or events through three primary pathways: (1) direct experience/exposure to some object or event; (2) informal communication with friends and associates, and (3) exposure to media coverage concerning aspects of the object or event (Tyler and Cook 1984). Pathway one has potential to exert the strongest influence on risk perceptions (Kasperson et al. 2003; Tyler and Cook 1984), but relatively few people interact directly with any major WD (i.e., few people will contract a disease, know someone who contracts the disease, have a pet or domesticated livestock contract a disease, or otherwise deal with the disease in everyday life). Pathways two and three describe culturally-mediated experiences; therefore, much of people's history of experience with a risk is really another cultural influence.

Heuristic activation

Heuristics are either innate to human-beings (i.e., evolutionarily engrained in our psyche), or they are formed over repeated cultural experiences (Tversky and Kahneman 1974). Just as cultural background can lay the foundation for developing heuristics, heuristic activation can lay groundwork for reliance on cognitive or affective processing (Thalmann and Wiedemann 2006). Heuristics provide mental shortcuts for making decisions, and thus may limit cognitive processing, allowing affective thought processing to assume a more dominant role (Kahneman and Frederick 2002). Reliance on affective processing in itself has been considered one type of heuristic (Slovic et al. 2004).

Heuristics can only be activated if they have been developed before a risk event occurs. If the characteristics of a risk event, or society's framing of that event, do not activate a decision-making heuristic, one will continue forming perceptions about the risk through systematic processing (Chaiken 1980). Activation of heuristics supports reduced cognitive processing, as the rule-of-thumb leads to a reaction similar to a defense mechanism early in the process of risk perception formation (Kahneman and Frederick 2002). Systematic processing means that people absorb and analyze risk information in a more effortful manner (Kahlor 2006). While systematic processing may favor subsequent cognitive processing, affective processing could result as well (e.g., highly sensationalized media coverage may make even those who carefully assess risk information develop strong emotions about the risk [Thalmann and Wiedemann 2006]).

An example of using heuristics to think about a WD comes from example 3 in the previous section; cattle farmers equated presence of elk with risk of bovine TB. They did not objectively know that the elk were infected with TB, but came to associate presence of elk with presence of bovine TB, and developed risk perceptions founded on this mental shortcut (Brook and McLachlan 2006).

Affect and Cognition

Theories on affect and cognition can be placed into three main categories: theories postulating affective primacy, theories asserting cognitive primacy, and linkage theories that see cognitive and affective processes as working in concert, without claiming that either precedes the other (Neuman et al. 2007). This third category, linkage theory, has garnered considerable

attention in the field of risk perception, with particular focus on dual-processing models, a form of linkage theory (Keller et al. 2006; Slovic and Peters 2006; Slovic et al. 2004; Loewenstein et al. 2001). By definition, dual-processing models separate thought processing into two categories, each operated by different neural systems: controlled (cognitive) processing and automatic (affective) processing (Deutsch and Gerard 1955). Risk analysis researchers generally view thought processing as a trichotomy where either affective or cognitive processing or both will occur in each decision-making process (Spezio and Adolfs 2007; Slovic and Peters 2006; Loewenstein et al. 2001).

The level of affective processing can be influenced by vividness (e.g., perceived severity) and spatial or temporal proximity to a risk (immediacy) (Loewenstein et al., 2001). Vivid and immediate risks may generate powerful emotions and foster affective processing (Sherman et al. 2002). The ancillary context in which a risk emerges could also shape the level of cognitive and affective processing. For example, a dearth in media coverage on a risk may lead a stakeholder to feel lacking in information to make a decision, therefore fostering information-seeking behavior and associated cognitive processing (Kahlor et al. 2006; Griffin et al. 2004). Another stakeholder may develop perceptions about how the threat is being handled by institutions responsible for management; these actions could then be evaluated cognitively for whether they are improving or exacerbating the threat situation, or considered affectively if the stakeholder has little trust in the management institution(s) (Needham and Vaske 2008; Heberlein 2004; Vaske et al. 2004; Slovic 1993).

Questions for further research

Empirical evidence from the examples earlier in this report shows that WD risk perception research has identified possible routes for improving agency communications about WDs. Comparing the third and fourth examples to the first and second examples indicates that a better understanding of factors influencing risk perception formation produces more fodder for construction of recommendations for agency communications. No study to date, however, has investigated systematically those factors theoretically identified as most important to risk perception formation. We identify the need for a research approach that is comprehensive in addressing multiple influences on risk perception formation, and as such, could be applied to social science research on WDs across contexts. A research protocol of this sort would ensure that important and potentially subconscious influences (e.g., affective processing and cultural background [Spezio and Adolphs 2007; Douglas 1992]), are not ignored. Use of such an approach would also facilitate comparison of risk perceptions across studies. It would allow researchers to identify how different cultural backgrounds, activated heuristics, and modes of thought processing can lead to varying risk perceptions.

The theoretical research presented in the previous section suggests that investigating stakeholders' cultural backgrounds, perceptions about the ancillary risk context, history of experience, activation of heuristics, and relative use of cognitive and affective processing may provide a reliable and systematic manner for identifying factors influencing risk perceptions. Methods exist for measuring the effects of cultural influences (Rayner 1992), heuristics (Fischhoff 2002), and affect and cognition (Neuman 2007) on risk perception formation, but

discussion of such methods lies beyond the scope of this literature review. Moreover, while leading risk perception theorists stress the need to study a range of influences on risk perception formation, they also caution that any measurement of potential influences must take note of the particular context in which a risk emerges; a comprehensive research approach can be used, but must be tailored to fit each study (Pidgeon et al. 2003). Further inquiry is needed to understand how risk perception research, and the related recommendations for communications coming from that research, could benefit from systematic measurement of constructs essential to risk perception formation.

Questions of interest for future investigation include: What trends could a research approach applied across contextually different studies on WD risk perceptions reveal? Would we see that, for a certain type of disease, one influence dominates public construction of risk perceptions, or would we find that influences vary across social and cultural contexts? Do stakeholder groups, whether geospatially or ideologically defined, form perceptions of disease risks by relying on the same influences across diseases, or do influences relied upon vary with different disease characteristics? The answers to these questions lie in results from empirical investigation that employs a comprehensive theory-driven approach to risk perception research on WDs, as detailed above. Reliable data on these and other trends could help a management agency develop a model for targeting communications (Zielinski-Gutierrez and Hayden 2006).

The feasibility of a comprehensive theory-driven investigation also deserves further exploration. Can, for example, methodologies used to measure affect and cognition in clinical psychological studies be effectively applied to research on WDs? Will research contexts be similar enough to allow for use of the same approach, or will contexts vary too much for application of similar methodologies across contexts to make sense? These questions probe whether a theoretically justified research approach can also be practically realistic. Answers can only be obtained through the design and application of such a comprehensive theory-driven approach to risk perception research on WDs.

Conclusions

This literature review provides empirical and theoretical clues about how recommendations for management agency communications could benefit from research on risk perceptions about WDs. Agencies would purportedly be able to use the research to construct public communications that closely address the public's most salient concerns and/or seek additional input from the public about those concerns. Despite the promise of using risk perception research on WDs in such a manner, to our knowledge no research has ever actually been used in this capacity, or if it has, no subsequent evaluation of its effectiveness has been performed and reported in peer-reviewed literature. Using research to create actual communications, and evaluating the effectiveness of those communications, is needed to understand more clearly how risk perception research on WDs can benefit management agencies.

Qualitative research that investigates the factors leading to risk perceptions across multiple contexts would be a valuable contribution toward constructing well-informed communications. Examining causes for concern in different cultural and physical contexts, and

across different diseases, would help answer many of our questions about trends in WD risk perceptions. This knowledge could then set the stage for quantitative studies that measure the relative importance of the various empirically-identified influences on risk perception formation. Using research to design communication efforts, followed by systematic evaluation of effectiveness, would be the final stages in the comprehensive theory-driven research approach we suggest.

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